Coma in Infancy and Childhood

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Coma is defined as an altered state of consciousness from which arousal due to appropriate stimuli is not adequately achieved. Such a definition of the state of coma is plagued with semantic problems, and terminology describing various comatose states is vast and even more ambiguous when applied to the infant. Rather than using such terms as coma, semicoma, stupor, or obtundation, it is better to describe the physical state of the unresponsive patient. The description should include the patient's appearance, movements either spontaneous or elicited from stimuli, the patient's response to the stimulus, and the nature of the stimulus, whether voice, pressure, or pain. A detailed neurological description is not warranted when describing the comatose state, but it is appropriate to include whether or not respirations are spontaneous or supported, and the patient's cardiovascular state. Pupillary size and activity should be included in the description of the stuporous patient. The comatose state of an infant may be much more difficult to recognize and is often confused with physiological sleep states. An infant is considered to be in a coma when there is no appropriate response to shaking, pinching, visual, or auditory stimuli. As with the older child, a detailed description of the state is necessary. More difficult to recognize in infants and children are the less severe forms of coma, especially since fluctuating metabolic situations with rapid changes can occur and the state of consciousness may change equally rapidly. Notwithstanding these difficulties of definitions and recognition, a classification of coma (Table) in an infant and child is essential.

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Pathophysiology of Coma

From animal studies it appears that the ascending reticular activating system is chiefly responsible for the state of consciousness. When this system is damaged or destroyed, a slow synchronized electroencephalogram (EEG) and coma ensue. The ascending reticular activating system appears to include the rostral pons, pons, hypothalamus, and midbrain, and has indistinct boundaries with a multitude of interconnections involving the brain stem and forebrain. Physiologically, there are ascending and descending systems with many feedback mechanisms. Anatomically, this polysynaptic system has not been adequately deciphered; however, the area rostral to the pons appears to be essential for the maintenance of consciousness.

In extrapolating data to man many inconsistencies occur, such as hypothalamic destruction with sparing of midbrain reticular formation, followed by sustained somnolence. Because of the quality of the cognitive functions of the human cerebral hemispheres, substantial lesions of either or both hemispheres will interfere with mental integrative functioning; the more diffuse the lesion the more it affects the state of consciousness, whether or not associated brain stem lesions exist.[1] Eventually, irrespective of the insult causing changes in consciousness, the ultimate common pathway is the blood supply of the cells with oxygen and glucose necessary to maintain mitochondrial activity and intracellular metabolism, as well as to maintain membrane stability with ionic fluctuations and neurotransmitter release. Recently it has been shown that in head trauma serontonin and homovanillic acid levels change, indicating that basic neurotransmitter dysfunction does occur; therefore,

A Classification of Coma in the Infant and Child

SEIZURES

INFECTIOUS CAUSES
- Meningitis
- Encephalitis: Viral, Protozoal, Rickettsial
- Severe systemic infection

TRAUMA
- Subdural
- Concussion
- Hemorrhage: Subdural, Extradural, Intracranial, Subarachnoid

MASS LESIONS
- Neoplasms
- Hematomas
- Infective
- Hydrocephalus

VASCULAR LESIONS
- Thrombosis
- Vasculitis
- Embolization

DEGENERATIVE DISEASES

METABOLIC CAUSES
- Oxygen deprivation (Hypoxia or Anoxia): Cardiac, Pulmonary, Ischemic
- Hypoglycemia
- Hepatic coma
- Uremia
- Electrolyte abnormalities: Sodium, Potassium, Calcium, Magnesium, Water
- Acid base abnormalities
- Hormonal dysfunction: Inappropriate ADH
- Encephalopathy: Reye's syndrome

POISONS
- Antihistamines
- Barbiturates
- Belladonna
- Drugs of abuse
- Lead and other heavy metals
- Organophosphates
- Phenothiazines
- Salicylates
- Tranquilizers (Benzodiazepines)
- Tricyclics

to meet the high-energy demands required, a functioning metabolism is essential.[2]

Under normal physiological conditions, glucose is the main substrate used by the brain, but in certain circumstances ketones may be metabolized. As the brain's glucose reserve is minimal, any alteration of the state of consciousness may be an early sign of hypoglycemia. Certain enzymatic cofactors such as thiamine and pyridoxine are required to utilize the glucose; absence of these in the diet may affect the status quo of the brain. A constant oxygen supply to the brain is vital and when this is deficient, lactic acidosis quickly occurs. The brain consumes 15% to 20% of the total body's oxygen needs and this oxygen consumption increases rapidly during seizures. Cerebral blood flow is equivalent to about 15% to 20% of cardiac output and can increase or decrease under particular physiological stimuli, for example, changes in P_{CO_2} or pH. Similar states with regard to the reticular activating system and cortical grey matter probably exist in the infant, but as yet, detailed clinical and anatomical correlation of stupor in coma is not available in the neonate.[3]

Signs, Symptoms and Diagnostic Approach

With the unconscious patient a rapid gross assessment is necessary to establish the brain's basic requirements in terms of blood volume, blood flow, oxygenation, and glucose. This initial management is essential to prevent permanent brain damage or death or both. Once the state of unconsciousness has been ascertained, cardiac output should be ascertained and adequate respiratory exchange maintained. In addition intravenous fluids containing glucose should be administered after blood has been drawn for laboratory tests. When the initial steps of establishing an airway and observing adequate cardiac output have been taken, the patient should be examined to establish the cause of the coma.[4] A general evaluation may give clues to the diagnosis; specific entities to be observed are cutaneous abnormalities including birthmarks, skin punctures and

bruises, and skull trauma, ecchymosis, and rashes. Respiratory patterns may help in the localization of the dysfunction. Of particular interest are the apneic spells seen in premature newborns which may be related to brain stem immaturity or dysfunction.[3] The ears should be examined for hemotympanum. Heart murmurs may indicate endocarditis or brain abscess. Pupillary size and reactions may help localize the lesion. These are especially important in the deeply comatose patient when no history is available as metabolic encephalopathies usually have reactive pupils. A full neurological evaluation in the usual manner will help determine the process causing the unconsciousness.[5]

In children trauma is not always obvious and shaking an infant excessively may result in subdural hematomas. We have seen an infant who had inhaled a foreign body and was swung around in an effort to dislodge the article develop bilateral frontal lobe intracranial contusions sufficiently severe to cause death.

Subdural effusions in the infant with an open fontanelle are an infrequent cause of changes in consciousness; it is more likely that the underlying cerebral damage associated with the subdural hematoma may be responsible. Seizures associated with cortical damage have also caused problems of consciousness. Subdural and extradural hematomas in the infant with fused sutures have been the sources of problems; however, considering the size of the infant and child and the number of relatively severe falls, trauma, excluding the battered baby, is a relatively infrequent cause of coma. (The battered syndrome must always be excluded when observing trauma-induced unconsciousness in the infant and child.)[6]

Infection may cause serious changes of consciousness in the infant and child. Any neonatal infant who shows a non-physiological depression of its conscious state should be evaluated for meningitis. In the neonate and young infant this change of consciousness may be the first sign of an impending infection. Changes of consciousness associated with purpuric or ecchymotic rashes require urgent evaluation to exclude a meningococcal meningitis or Rocky Mountain spotted fever. All these infectious states in the young infant occur without any other typical signs of meningism. Thus, as part of the diagnostic work-up, immediate lumbar puncture is required. Supratentorial mass lesions or hydrocephalus are to be considered and spinal fluid may have to be obtained from other routes.

Infants and children with a history of seizures may frequently present with status epilepticus or in postictal states especially associated with noncompliance with drug therapy. Seizures may be due to any of a variety of causes and require an immediate evaluation for exclusion of treatable causes, such as metabolic dysfunction, noncompliance in medication, and certain poisons and toxins. Poisons and toxins causing coma require specific antidotes. It is essential that every comatose patient, infant and child, undergo immediate toxic screening of the urine and, if necessary, of serum, even when there is no history of ingestion; any delay may result in death. In our experience toxic screening revealed the presence of imipramine in the urine of a child who was admitted unconscious to our institution and whose parents had denied the existence of any drugs in their house. Unfortunately, the delay in performing the test resulted in the death of the child two hours later from what is a treatable condition. Poisons are listed in the coma classification and each one requires its own treatment.

Metabolic dysfunctions are probably the commonest causes of altered states of consciousness in the infant and child. They are not easily recognized and the signs and symptoms may be similar to those of an unconscious child who may or may not have reflexes present with or without brain stem signs but who usually shows intact pupillary reflexes and no neurological localizing signs. It has been our practice to evaluate the blood immediately with Dextrostix to rule out hypoglycemia. If indicated, calcium is given empirically, especially if the child is having a seizure. Routine laboratory tests to evaluate electrolyte status are obtained as soon as possible; arterial blood gases are monitored and the appropriate corrections made.

Reyes syndrome, with the associated encephalopathy, can result in profound metabolic coma, and the diagnosis needs to be considered in all comatose children where etiologies are in doubt. Depending on the type of metabolic dysfunction, specific treatment may be indicated, but in general the treatment is primarily supportive.

Evaluation

After acute treatment and assessment of a patient in a coma, an immediate EEG is done which frequently helps to establish the metabolic cause. The EEG is usually diffusely slow, and in the infant and neonate the slowness is difficult to correlate; however, suppression or diffusely slow, low-voltage EEGs may

be helpful. The advent of the computerized axial tomography (CT) scan has helped tremendously in the diagnosis of contusions and space-occupying lesions as well as acute hydrocephalus. In our institution this test is performed as an emergency procedure. X-rays of the skull are helpful in non-obvious trauma, and skeletal surveys are done if a battered baby is suspected.

Treatment

Once acute treatment has been established together with specific therapies, EEG, antibiotics, anticonvulsants, correction of electrolytes and acid base abnormalities, indicated surgery, and specific antidotes for poisons, the remainder of the treatment is supportive. The unconscious patient is nursed in an intensive care unit; if any problems are related to breathing, the patient is intubated and if necessary, respiratory therapy is instituted. After particular cerebral insults, cerebral edema may occur and specific precautions are taken for decreasing cerebral blood flow by hypoventilation while insuring that adequate oxygenation to the brain is maintained. Of particular importance is the onset of the inappropriate antidiuretic hormone (ADH) syndrome, and our practice has been to maintain these children on two thirds fluid maintenance in anticipation of the development of inappropriate ADH. This latter treatment has been a problem in sickle cell disease where acute crises have caused multiple vascular occlusions resulting in unconsciousness; in these circumstances we monitor serum and urine osmolalities regularly to anticipate inappropriate ADH.

Because of the association of cerebral edema with many metabolic unconscious states, we have routinely used two forms of intracranial pressure monitoring in conjunction with our neurosurgical colleagues: 1) a dural screw and 2) intraventricular pressure monitors. The latter form is especially helpful since intraventricular cerebral spinal fluid can be removed to relieve the increases of intracranial pressure. Although hyperosmolar agents have been used with this type of monitoring, we only use them with intracranial pressure monitoring unless a surgically correctable lesion is present such as acute hydrocephalus. Using this monitoring system we have successfully managed and treated the unconscious state in Reye's syndrome.

The management of consciousness changes in the neonate and infant is essentially the same as that of the child. In this group such changes have most frequently been caused by metabolic dysfunction, hypoxia, and intracranial hemorrhage. Correction of the metabolic state is essential in the treatment of the coma and seizures which are frequently associated with these metabolic changes. We have not used intracranial pressure monitoring with infants.

Conclusion

Coma in the infant and child requires that the physician always adhere to a specific plan, and that his actions be adequate to sustain brain function in order to prevent irreversible damage. The advent of intensive care units, advances in technology, and a better understanding of the pathophysiology of coma will help to decrease mortality and especially the morbidity associated with coma.

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